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Inhomogeneous Spin injection and detection in gold thin film

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Effective spin injection to nonmagnetic material gives rise to spin accumulation at anti-parallel magnetic configuration of two FM electrodes, which can be detected in the non local measurement.[1~4]If injection (detection) occurs homogeneously across the entire width of the sample and the sample film is very thin, then the baseline resistance in the nonlocal measurement is zero. Indeed, all of the fabricated spin valve devices ever reported have shown non-zero base resistance.[1~4] In addition, injected spin current usually produce inhomogeneous spin accumulation which appears to a different magnitude of voltage drop depending on the position of voltage probes on the detector.[4] It is meaningful to investigate the relation between the magnitude of potential drop represented by Δ and different voltage probe configuration in nonlocal measurement.

In the study, we performed nonlocal measurement with different voltage and current probe configurations on the lateral Py/Au/Py spin valve devices in order to address the cause of non zero base resistance as well as a large difference of non local signal depending on the location of injecting or detecting probes.

60 nm thick Au film was patterned to define Au channel by electron beam lithography followed by lift off process on an oxidized Si substrate. 80 nm thick Py ($Ni_{80}Fe_{20}$) electrodes with a different aspect ratio being separated by a distance of 0.2 um ~ 2.2 um are fabricated on a pre-patterned Au channel. Junction area on Au transport channels was carefully cleaned by rf plasma prior to Py deposition in order to have good Ohmic contact. The resistivity of Au channel of our device is 4 Ωcm and the interface resistance multiplied by the interface area is 0.11 Ωm^2 at 15K. The nonlocal measurements were carried out at different voltage probe configurations by the standard ac lock-in techniques at 15 K

We measured the non local spin valve (NLSV) signals in two different probe configurations. Voltage probe between 4 and 5 is called "A" configuration and contacting 5 and 6 is "B" configuration when the current flows from 1 to 2. For "A" configuration where the current and the voltage probe locates at the same side on the border of Au channel, Δ is 0.2mΩwhile for

"B" Δ is 0.1mΩ which is half in magnitude than that of "A". We have done the same measurement for 10 devices with different Au channel gap and width in total and obtained the consistent result that "B" configuration is always lower than "A" in the magnitude of Δ depending on the channel length as well as gap between injector and detector. Spin diffusion length of Au channel with 4 Ωcm resistivity is evaluated to be 170 nm. We believe this is mainly attributed to both factors: first, the point contact forms between the injector and Au channel producing inhomogeneous spin injection, and second, effective spin travel length starting from the point contact affects observed Δ in two measurement configurations of "A" and B". In conclusion, inhomogeneous spin accumulation initiating from the point contact between an injector and Au channel induces the different distribution of spin accumulation flowing into a detector.

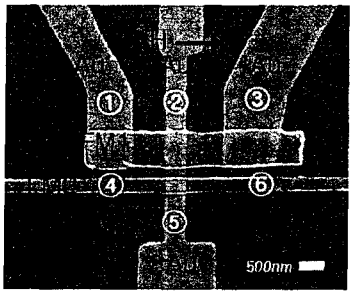

Fig.1. SEM picture of the lateral mesoscopic Py/Au/Py spin valve device

References

[1] M. Johnson, Phys. Rev. Lett. 70(14), 2142 (1993)

[2] F. J. Jedema, A. T. Filip, and B. J. van Wees, Phys. Rev. B 67, 085319 (2003)

[3] J. Ku, J. Chang, S. Han, J. Ha and J. Eom,Appl. Phys. Lett, 88, 172510(2006).

[4] T. Kimura, J. Hamrle, Y. Otani, K. Tsukagoshi, Y. Aoyagi, J. Mag. Mag. Materi. 286, 88 (2005)